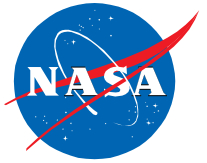

E-DECIDER Disaster Response Products and Decision Support Architecture

12 November 2014

ESIP Disaster Response Telecon

Maggi Glasscoe

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Jet Propulsion Laboratory
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Key requirements for products

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- Disaster response operates on a number of timelines
  - Immediate (crucial first minutes to hours following the event) – rapid results to focus initial response efforts
  - Intermediate (hours to days following the event) – continued response, refining initial results and assessments
  - Longer term (weeks to months) – identify areas where repair of infrastructure needs to be addressed

- Must identify where deformation is greatest and likely damage has or is likely to occur
  - This will allow decision makers and responders to focus response efforts
- Format and distribution
  - Standards compliant, georeferenced data products
  - Standards compliant distribution services
- How data is currently represented may not be easily understandable or interpreted by users
  - Must move beyond science products to decision support/response products

JPL Disaster Response Timeline

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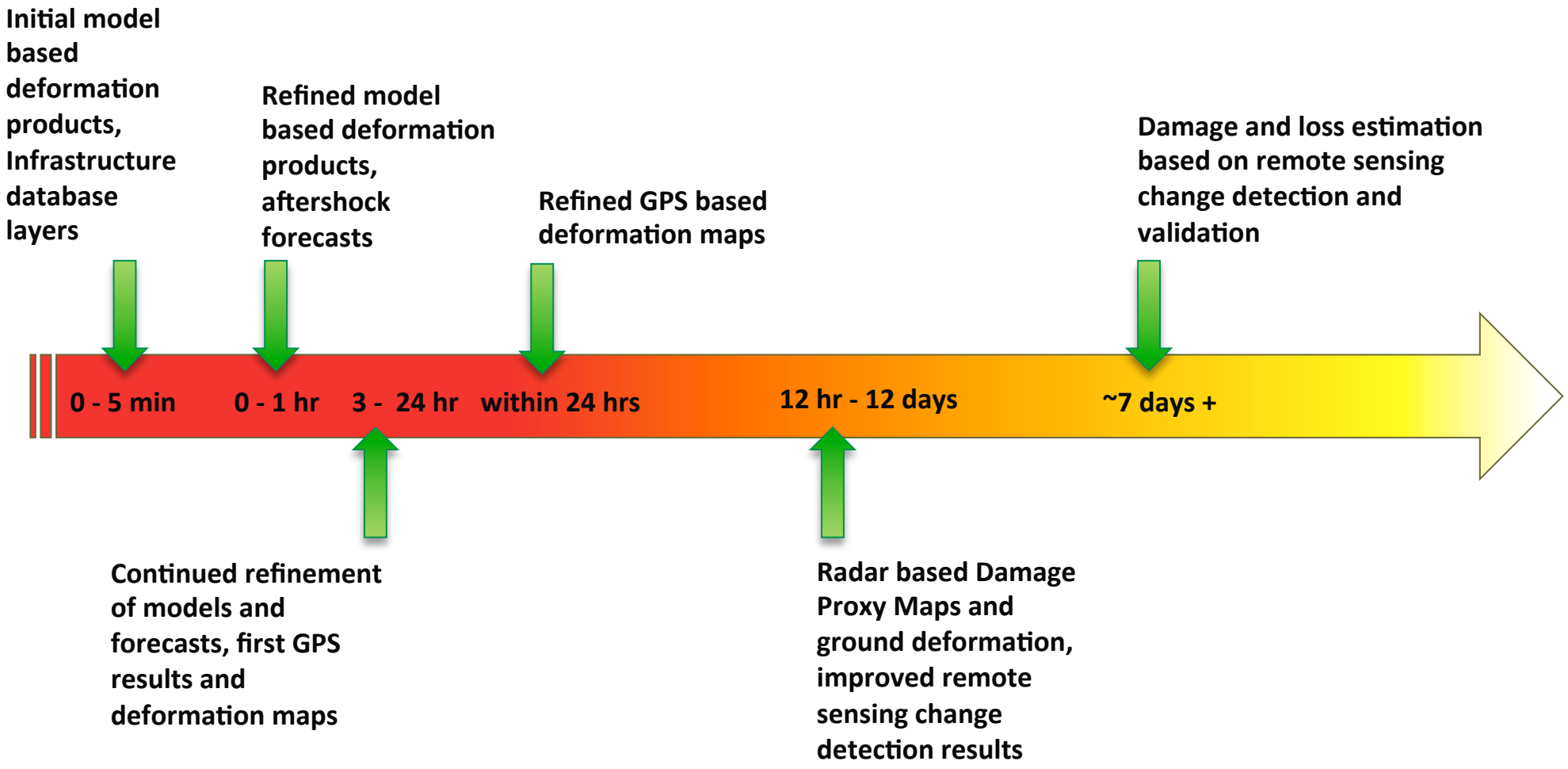

E-DECIDER Disaster Decision Support Platform

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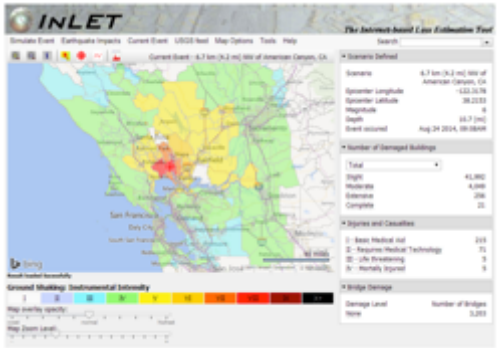
E-DECIDER

Emergency Event

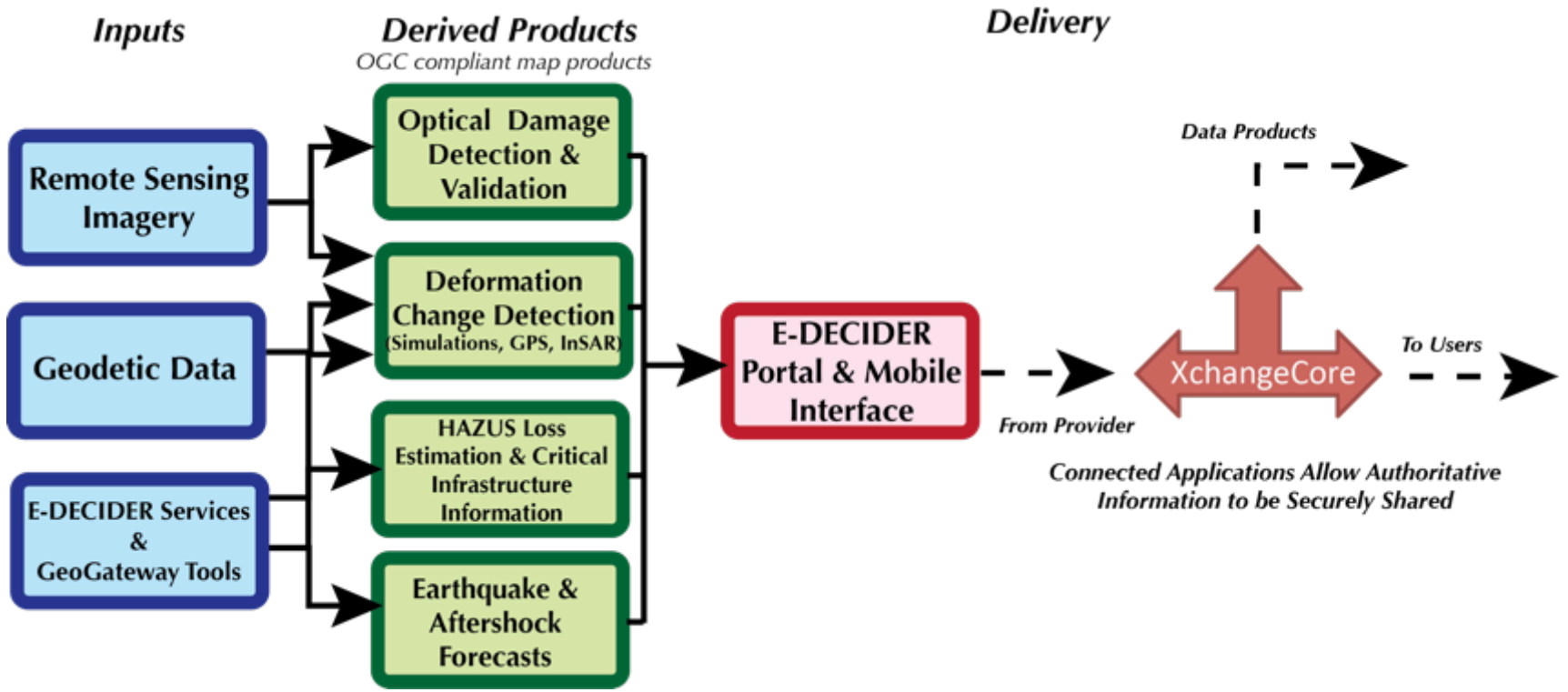
Generate Products



InLET (Internet Loss Estimation Tool) Rapid Post-Event Damage and Casualty Estimates

Deliver to Decision Makers

E-DECIDER Workflow



- Converts geophysical simulations and remote sensing observations into data products relevant to emergency preparedness and response communities
- Exploits recent advances in simulation modeling, crowdsourcing, loss estimation, machine learning, image processing and geospatial intelligence for enhanced emergency response after large natural disasters
- Serve as a gateway to enable the delivery of NASA decision support products to decision makers and responders
- Driven by the need for rapid and accurate post-event information that enables end-users to deploy limited resources during the early stages of a disaster

Data Exchange to End Users

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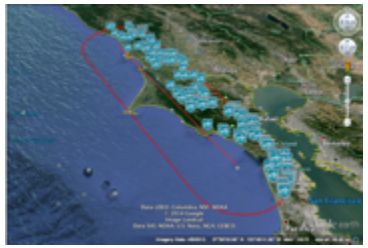
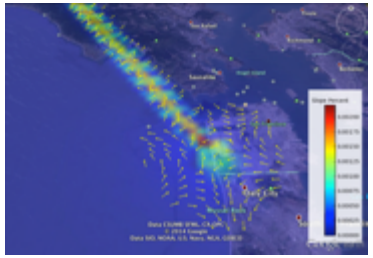
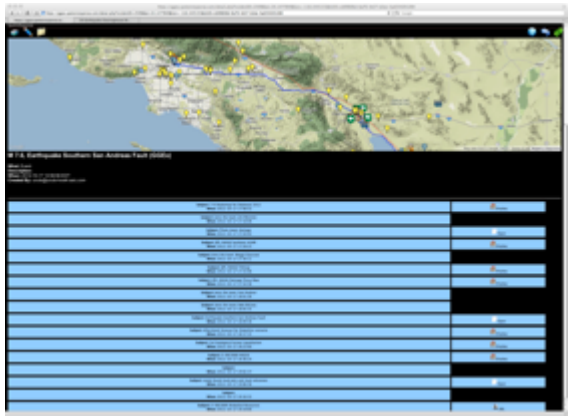




Working in partnership with CA Earthquake Clearinghouse, CalOES, CA National Guard, FEMA, local governments, and other agencies

XchangeCore



Products Generated → **Authoritative data securely shared** → **Users query products (Spot On Response, NICS, etc)** → **Pass on to Decision Makers (local, state, federal)**

Infrastructure Database Service: Product layers with overlays

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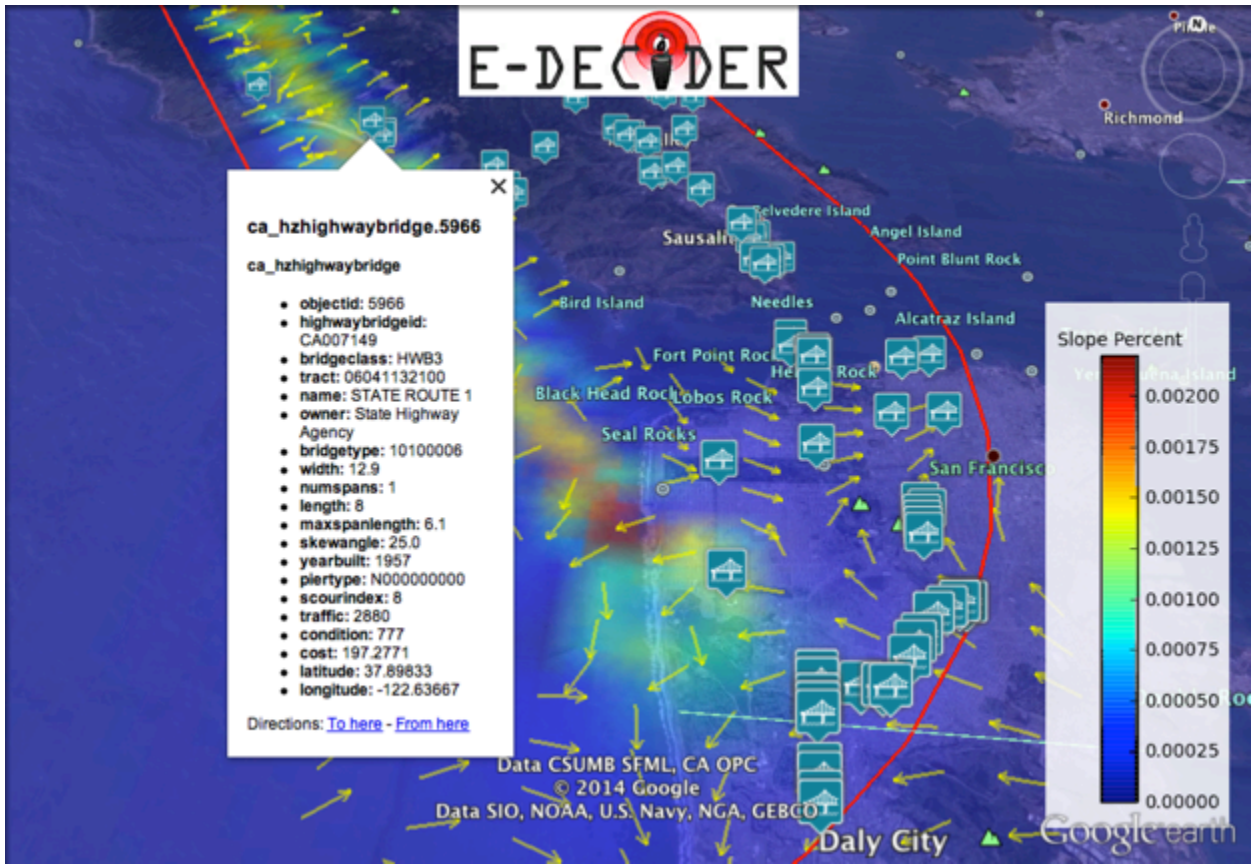
- The tilt or slope change map indicates where vertical changes in the surface have occurred. This is indicated with a color scale showing areas of greater slope change and arrows indicating the direction of change.

- Critical infrastructure that may have been exposed to damage can be viewed by specifying an epicenter or fault rupture parameters and radius of interest and then listing the items of interest.
- Damage and loss estimation is supported for site specific evaluation.



Infrastructure Database Service

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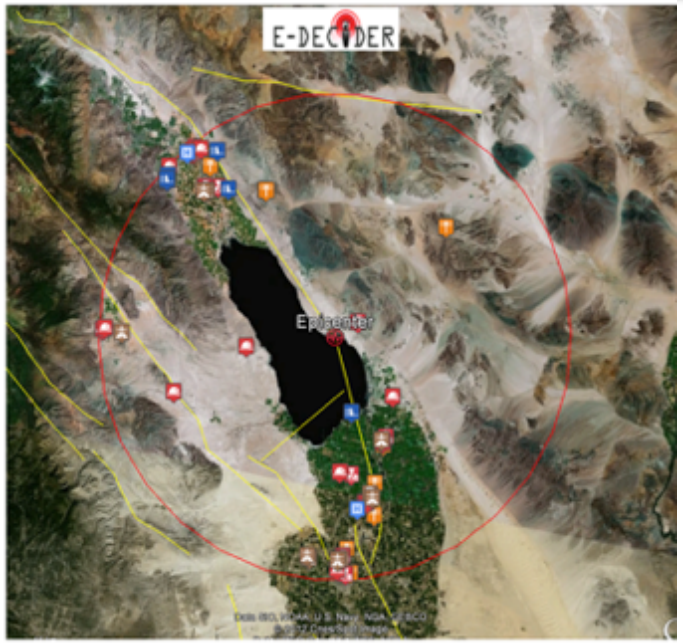
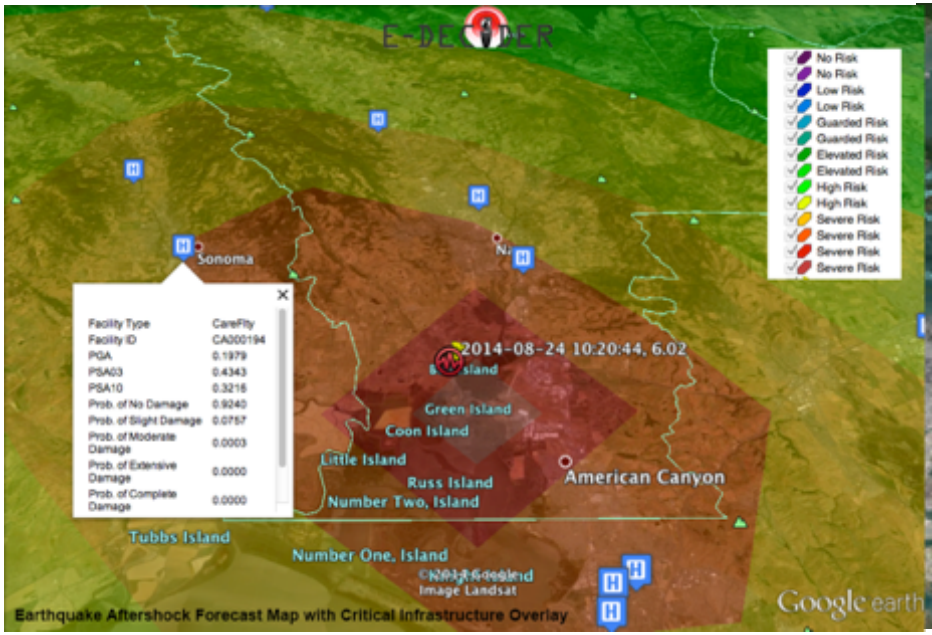
- Enables user to access near 30 FEMA critical infrastructure information layers with damage/loss estimation overlaid upon map data products from E-DECIDER and QuakeSim/GeoGateway (or others)
- Supports spatial query for broad range of emergency situations: point (e.g. earthquake), line (e.g. tornado, fault rupture), and polygon (e.g. flood, wildfire), and user-specified search distance; bounding box search is now supported





Model Products:
Napa Earthquake Response Day 1

Jet Propulsion Laboratory
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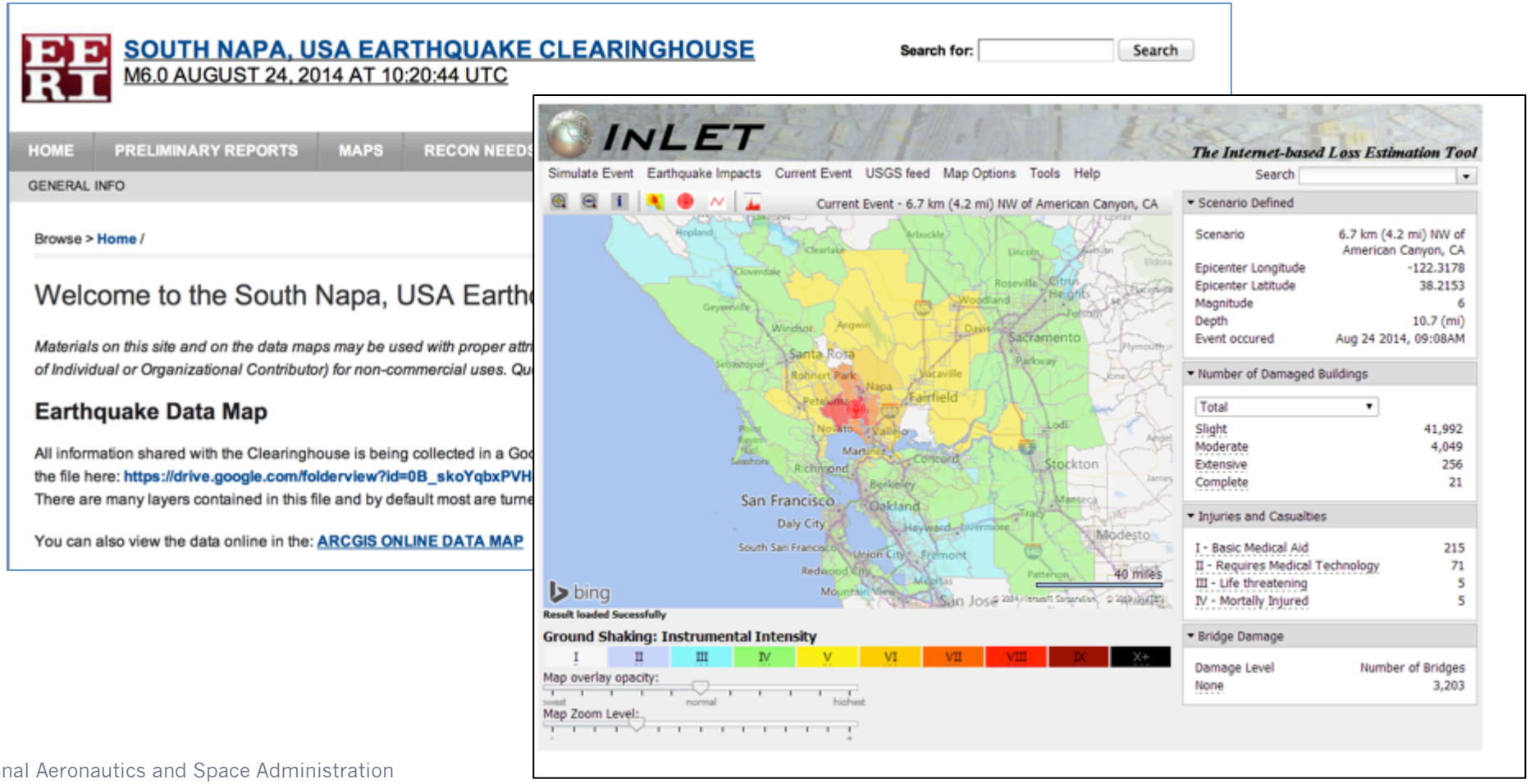
- Map data products, including a rapid damage and loss estimate, were provided to California Earthquake Clearinghouse within 24 hours of the event
- Information can aid in prompt allocation of resources



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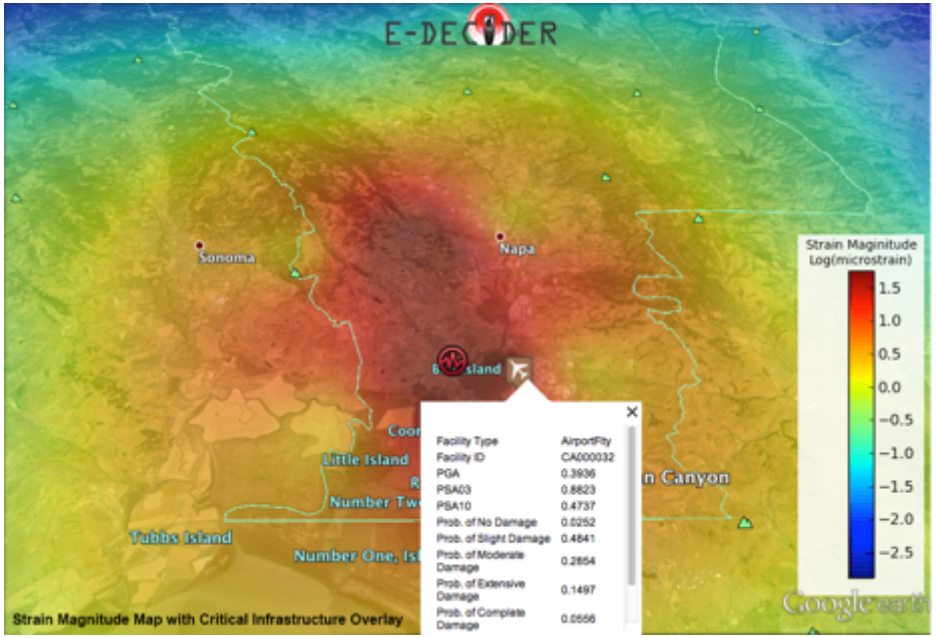
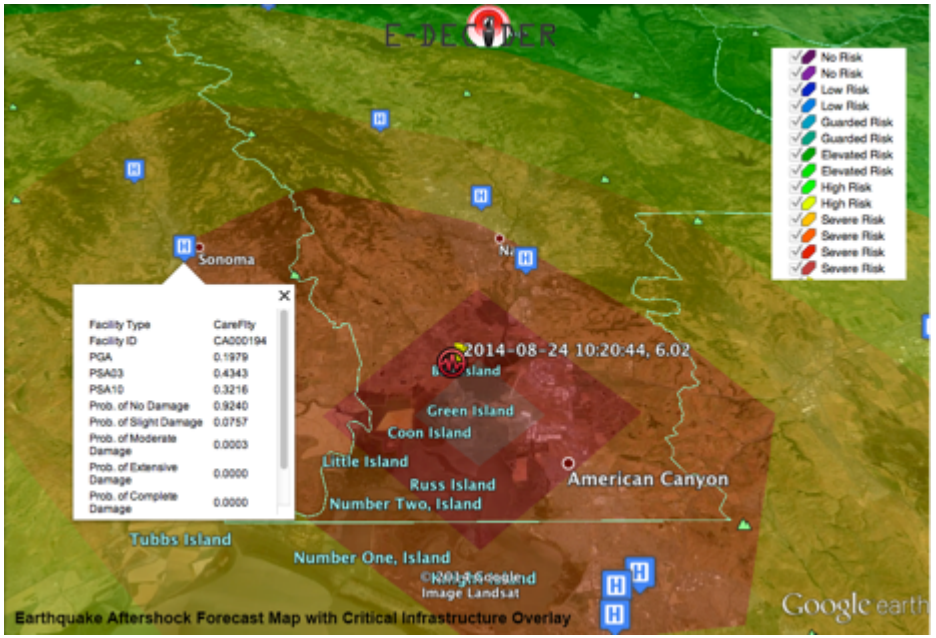




Strain Magnitude Map with Critical Infrastructure Overlay

Highlights areas where greatest ground deformation (motion) has occurred based on a fault model. Once GPS observations are available, the model can be refined and deformation better constrained. These maps provide an early estimate of where the deformation has occurred, and where damage may be localized. Using the critical infrastructure overlays with damage estimates, decision makers can direct response efforts. The map shows an airport in the affected area that was predicted to have sustained minor damage. The infrastructure information contains both a damage estimate and location to help direct response efforts. With later satellite observations and field reconnaissance, this information can be verified.

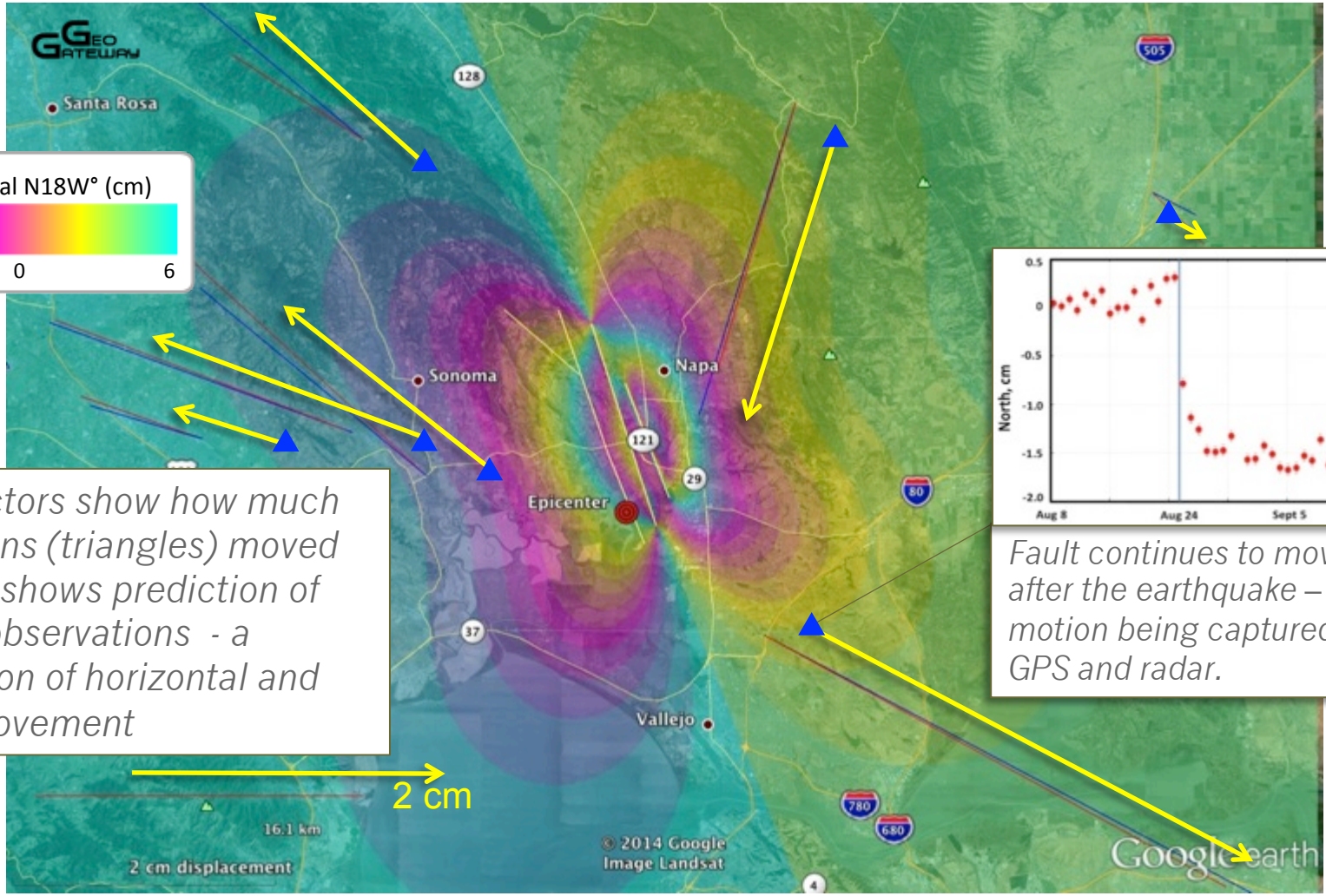
Earthquake Aftershock Forecast Map with Critical Infrastructure Overlay

Highlights areas where aftershocks are likely to occur. These maps show estimated aftershock risk in a color scale -- warmer colors represent higher risk and cooler colors lower risk. Using the critical infrastructure overlays with damage estimates, decision makers can better direct response efforts. For example, the map shows an emergency care facility within the affected area that was predicted to sustain slight damage, which can later be verified in the field.

Observing Permanent Deformation with GPS, Models: Napa Earthquake Response Day 2

Jet Propulsion Laboratory
California Institute of Technology

- GPS observations and fault models can provide maps of how much the fault and the surface moved, helpful for long-term recovery and revised hazard assessment.



- *Yellow vectors show how much GPS stations (triangles) moved*
- *Colormap shows prediction of UAVSAR observations - a combination of horizontal and vertical movement*

Fault continues to move after the earthquake – motion being captured by GPS and radar.

Observing Wildfires with UAVSAR

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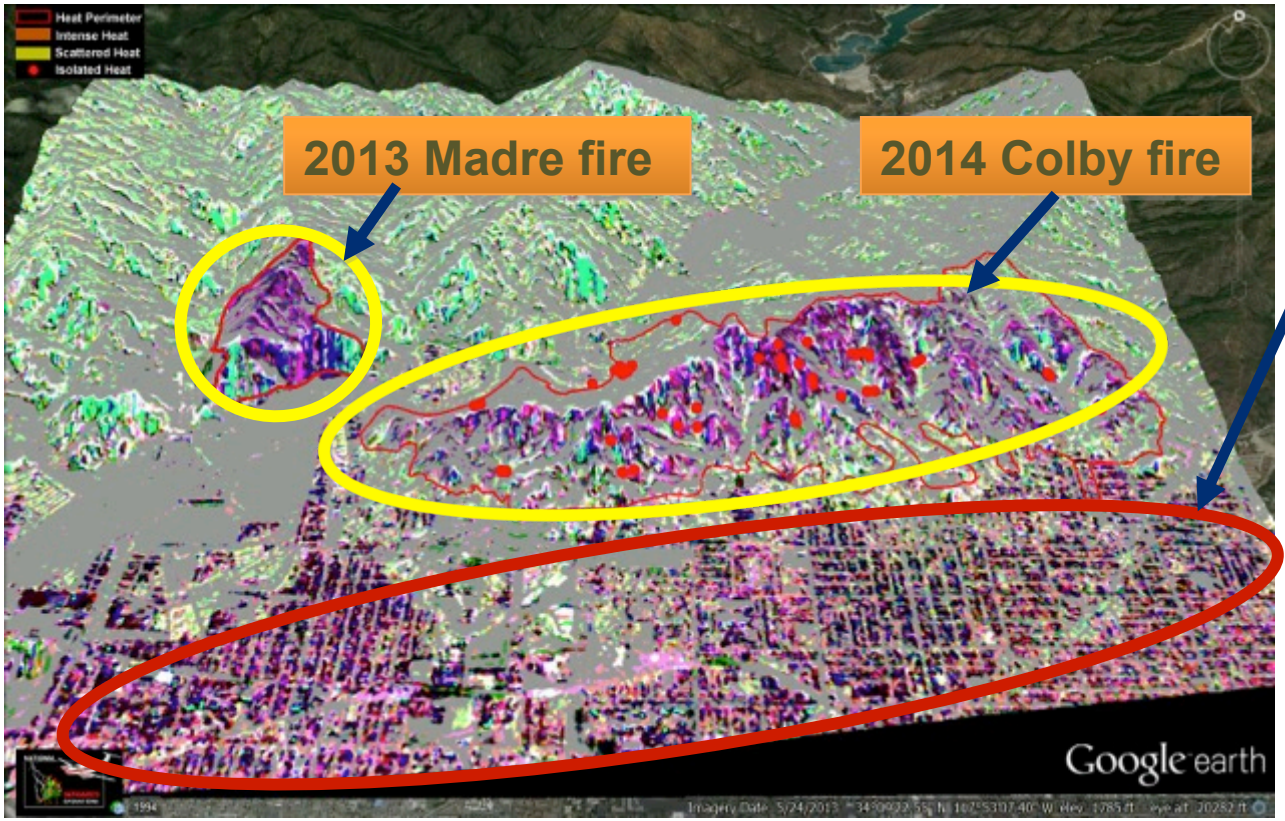


Complex built-up urban area changes

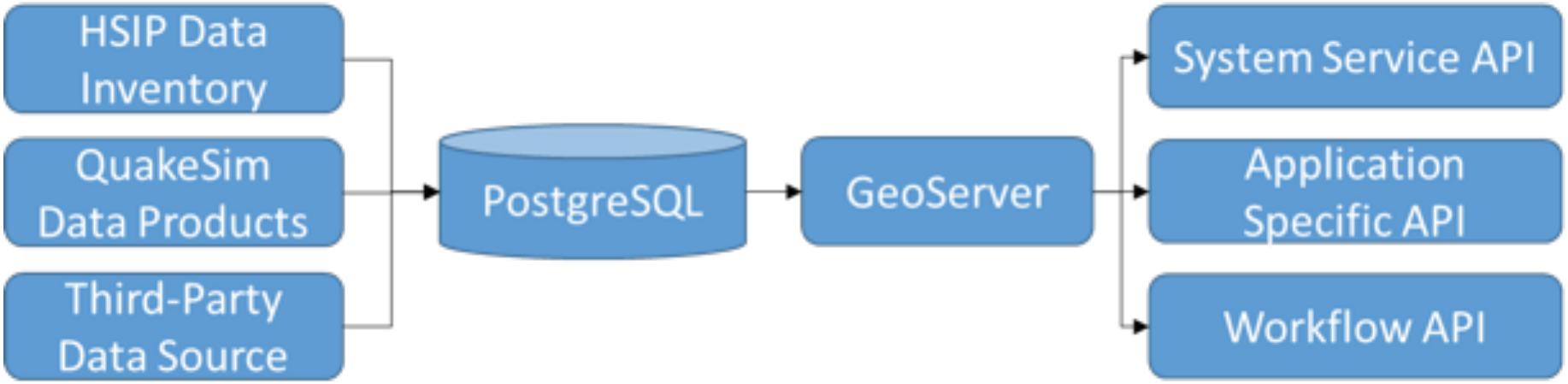
The red dots indicate where low resolution hot spots remain and where fire damage (purple, in yellow ovals) occurred . By adapting an image-change technique to airborne L-Band polarimetric image channels, this high-resolution map of fire damage (occurred between May 2013 and January 2014 observations) was made.

Highlight:

This preliminary work showcased a new capability directed toward wildfire emergency managers and government agencies responsible for response and remediation. This fire mapping may further serve as prior data for potential flood-induced debris flow and mudflow mapping. High-resolution mapping of fire damage in adverse conditions is demonstrated using repeat-visit airborne polarimetry, including data taken while the fire is in its active phase

Relevance: Fire-fighting and remediation professionals currently rely on satellite optical photography, which is often hampered by orbital delay, smoke, and clouds. E-DECIDER combined together radar polarimetry data, since radar data can be taken through clouds and smoke, day or night, and advanced image processing methods adapted to this data type to produce a visual map that can be easily accessed. This type of data product can be delivered rapidly to decision makers via E-DECIDER's website and through XchangeCore incident command software.

E-DECIDER Architecture



- Uses Apache Airavata (http://airavata.apache.org/), an opensource software framework for executing and managing computational jobs and workflows on distributed computing resources including local clusters, supercomputers, national grids, academic and commercial clouds
- Employs service-oriented architecture (SOA) based geospatial web service APIs, and totally committed OGC standards

E-DECIDER Architecture (2)

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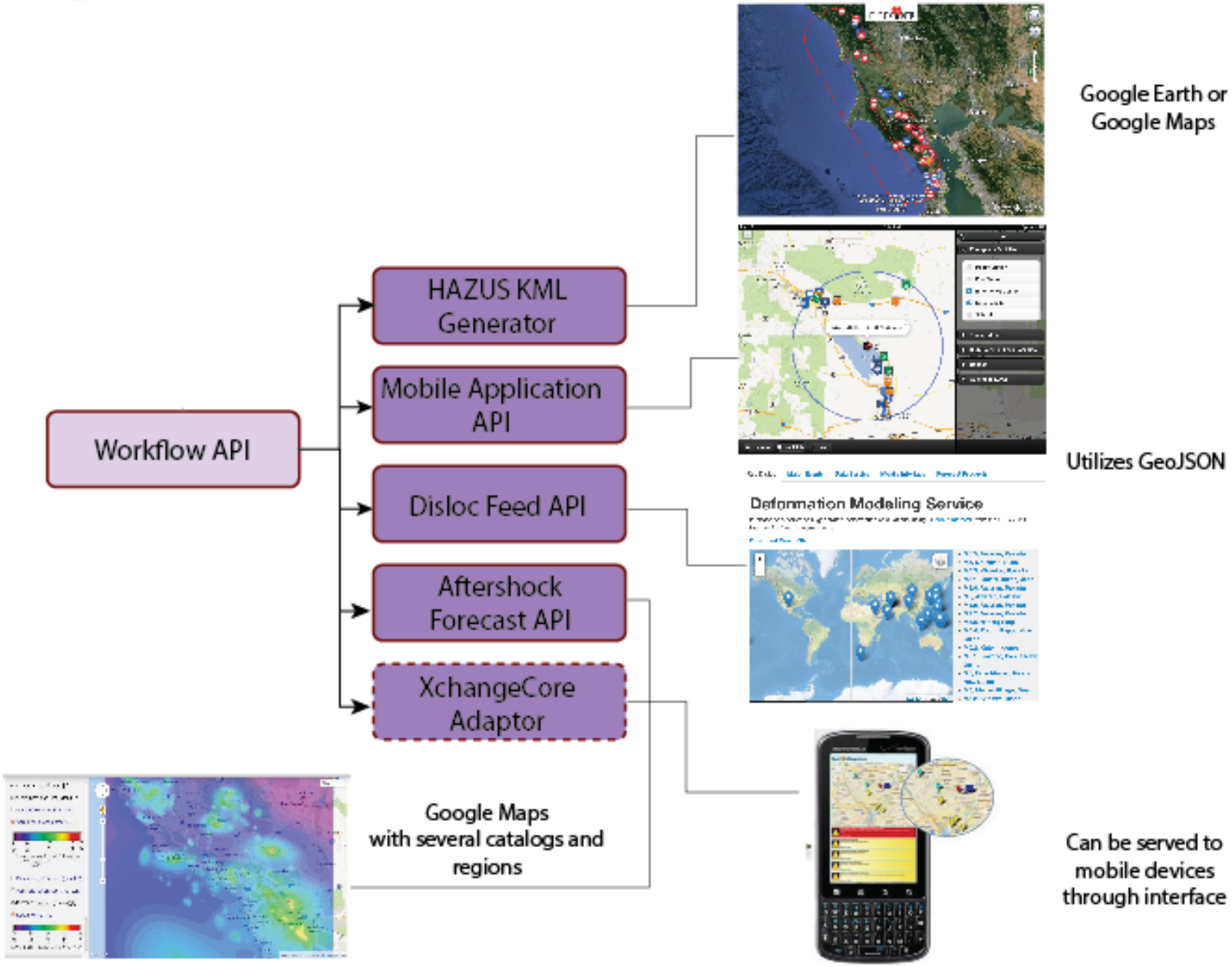
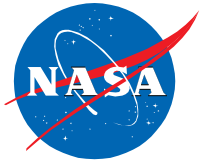


- Workflow APIs control E-DECIDER services



Thank you for your kind attention!

Questions?

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http://e-decider.org

http://www.californiaeqclearinghouse.org

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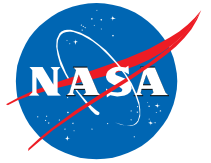

Backup

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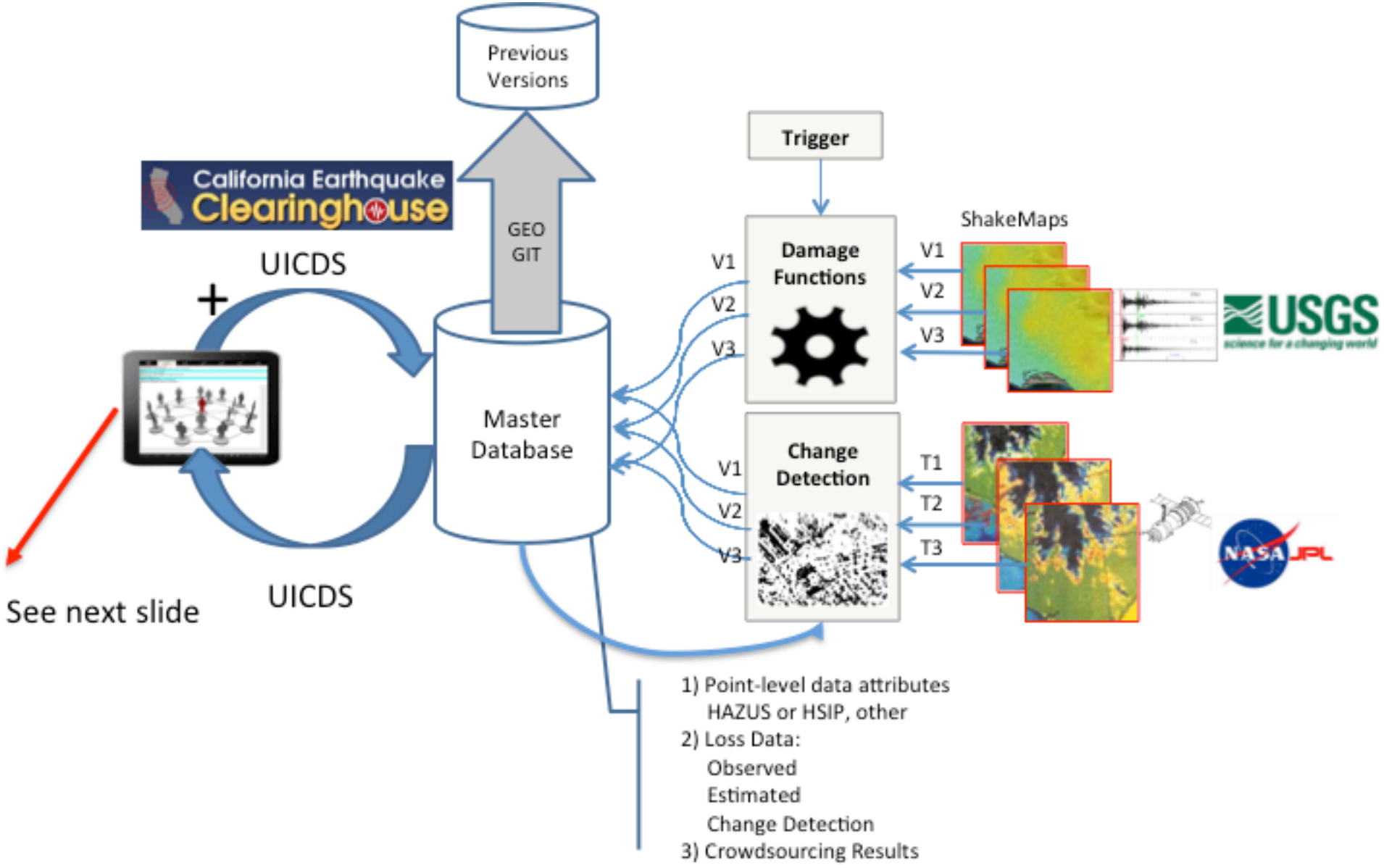
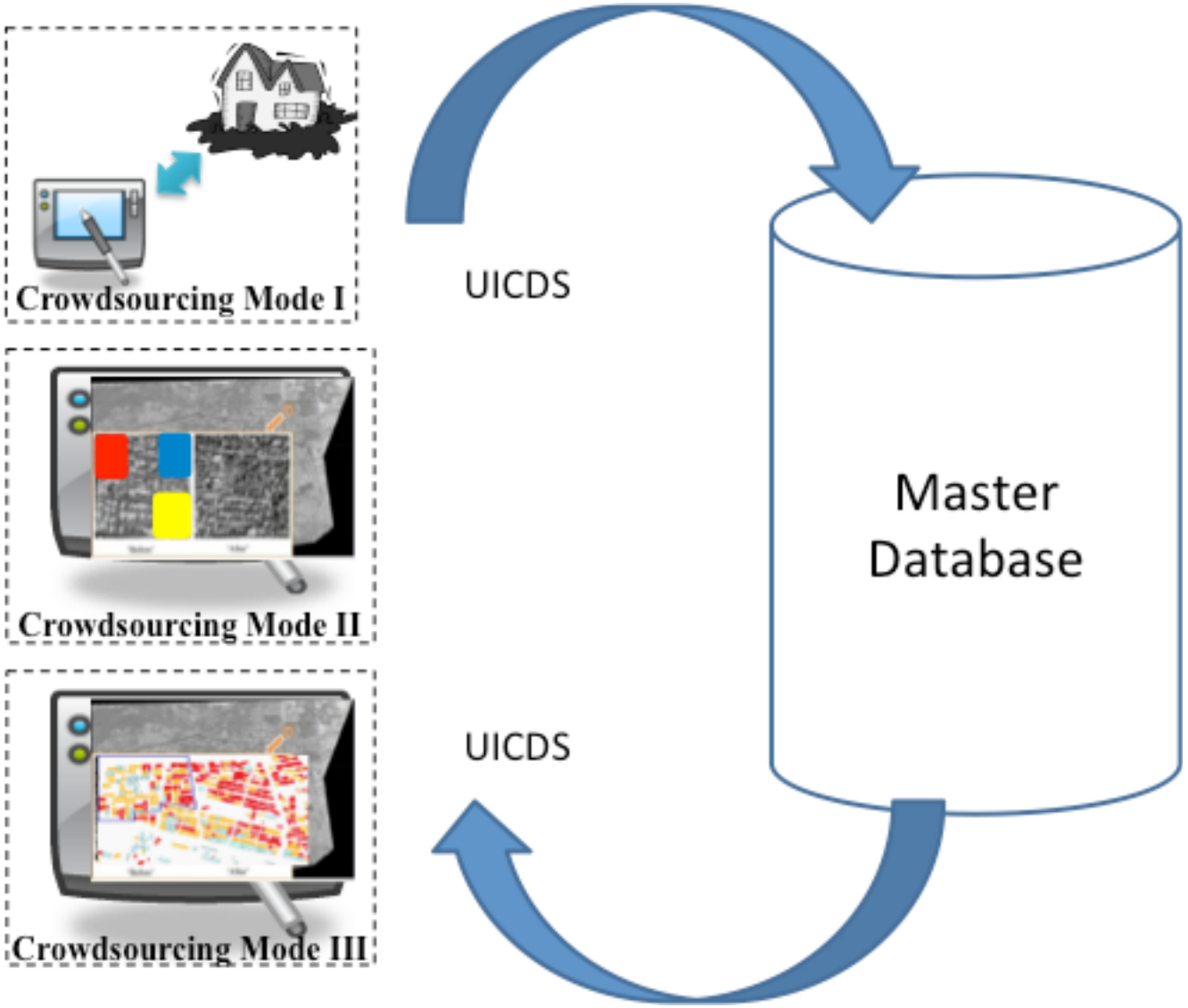
Damage/Loss Estimation - Database



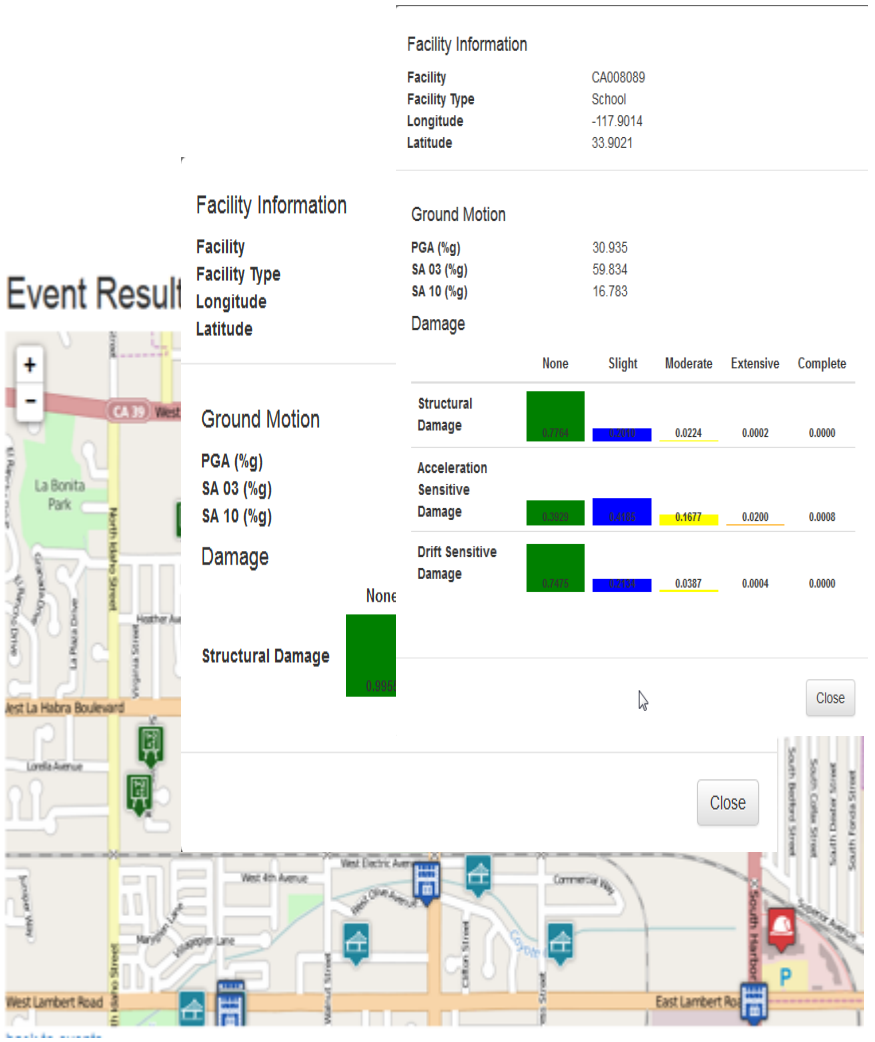
Database Architecture

Crowdsourcing component



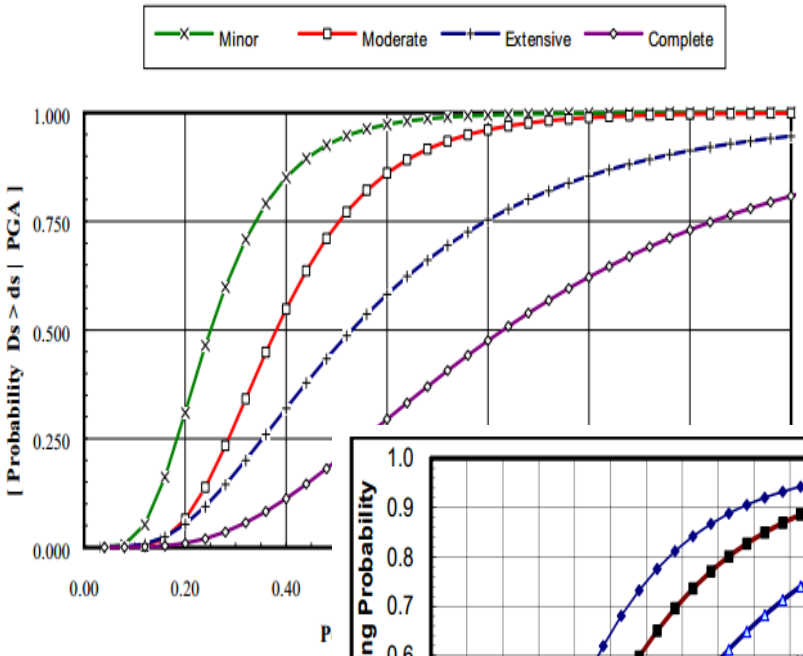
HAZUS analysis

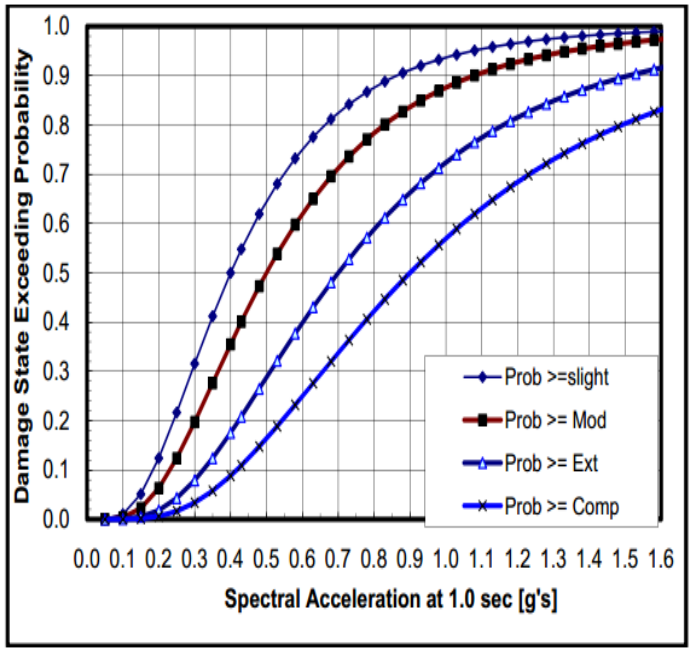
- USGS ground motions data from Shakemaps
- Direct Physical Damage assessment using HAZUS methodology
  - Essential High Potential Loss Facilities
  - Transportation Facilities
  - Utilities
- Result map for visualization



HAZUS analysis (cont.)

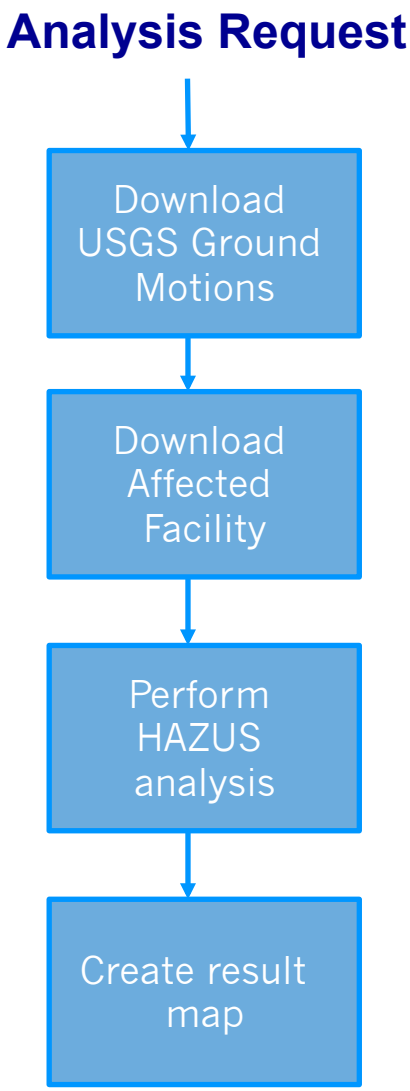
- Performs Ground Failure analysis based on site soil and liquefaction condition
- Customize fragility based on facility parameters
- Damage probability analysis



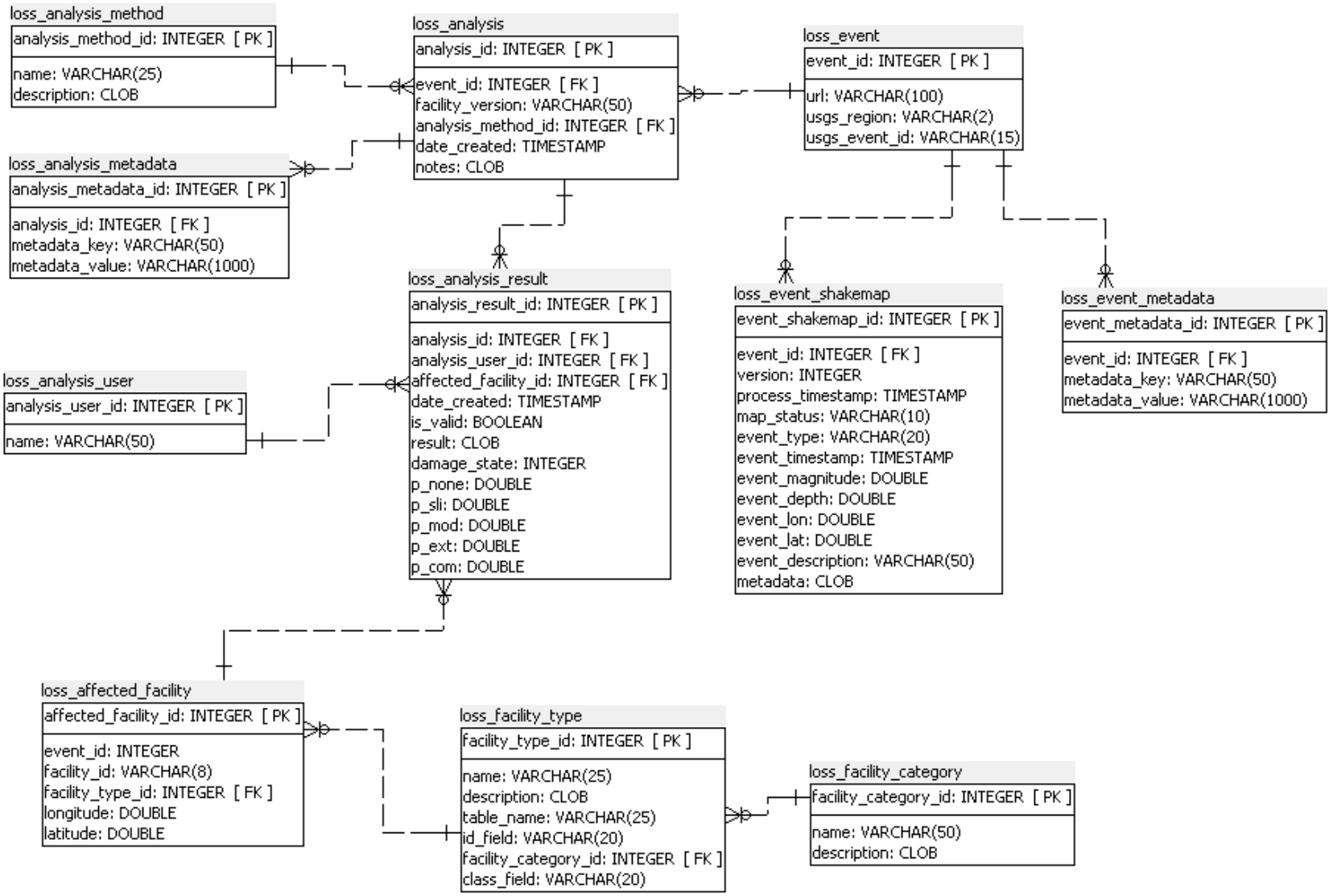


HAZUS analysis (cont.)

- Automatically downloads required data
- Modular and self-contained design
- Fully integrated with other components of project as web service



HAZUS Database Schema



Row based design allows the system to be expanded easily to include many sources of damage estimates.

Collaborative Disaster Damage Mapping (CDDM): A New Protocol

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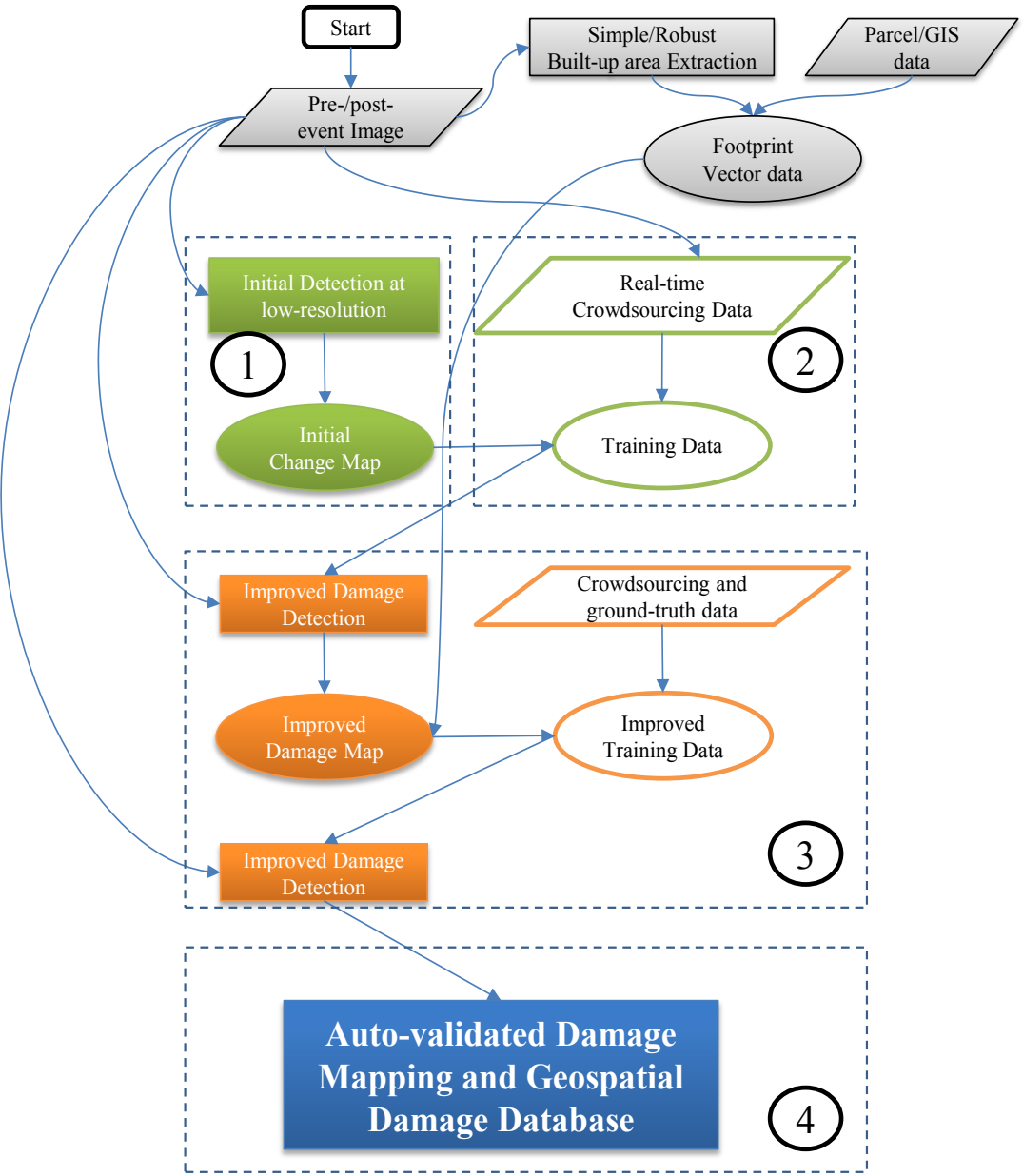

- Integrating Remote Sensing and Crowd-sourcing
  - RS – Large-scale damage detection and GIS analytics
  - CS – Distributed human sensing and ground-truthing
  - Dynamic integration through mobile-cloud computing
- Further cross-validating with HAZUS-MH

Damage detection from high resolution remote sensing imagery

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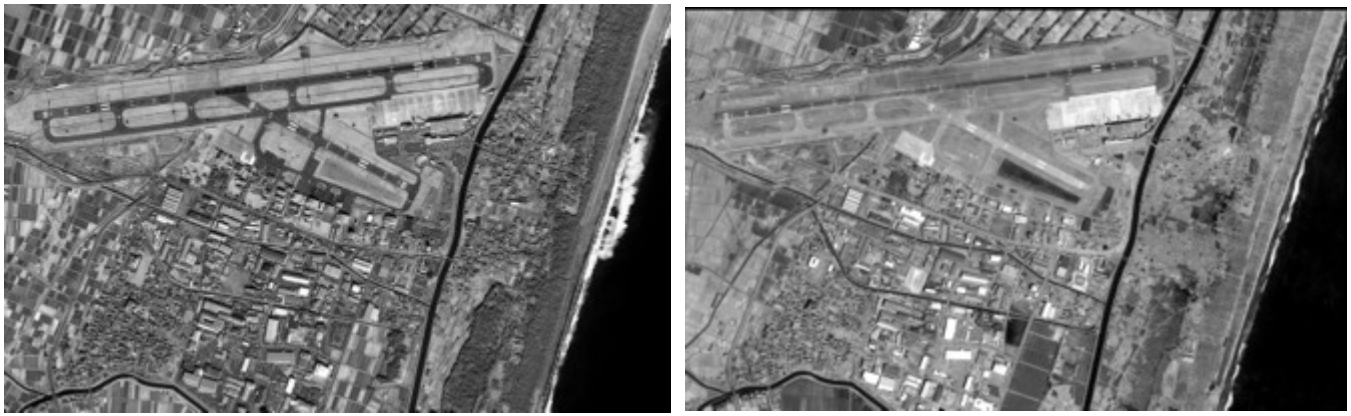
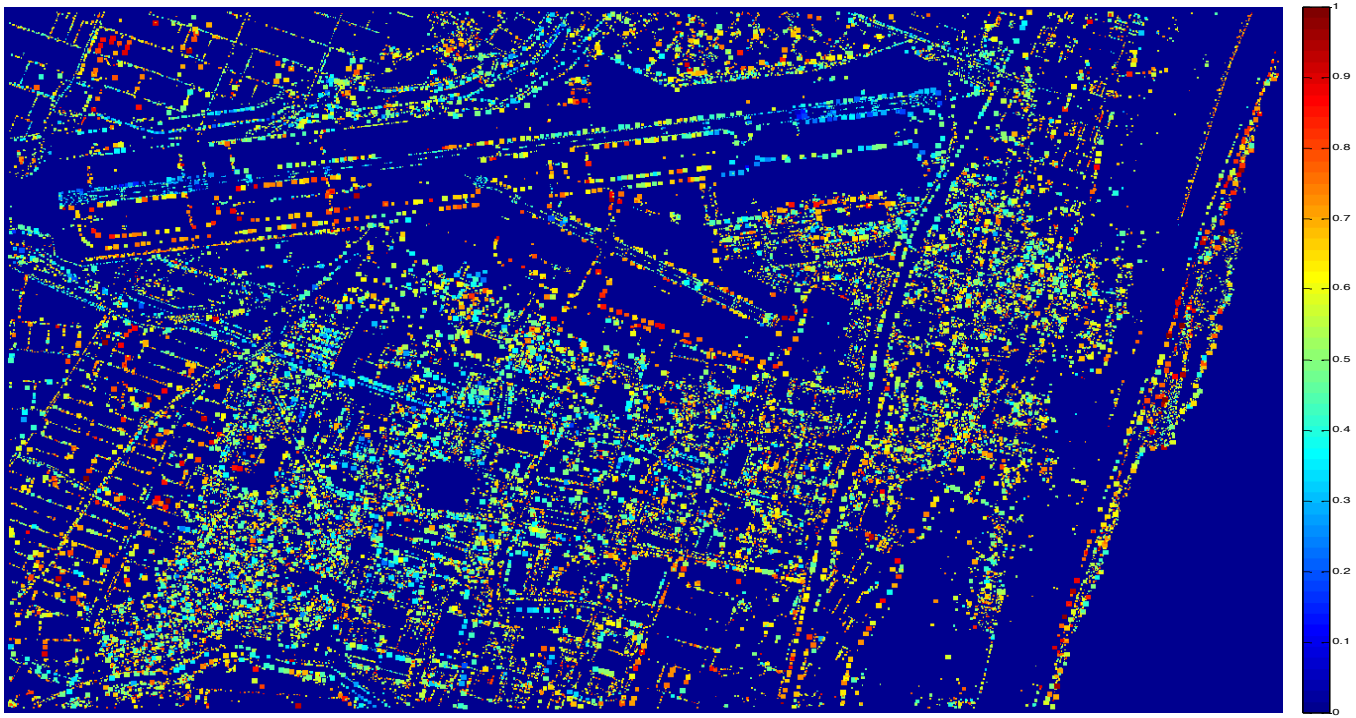
California Institute of Technology



High resolution before and after images of study area



Initial damage detection analysis

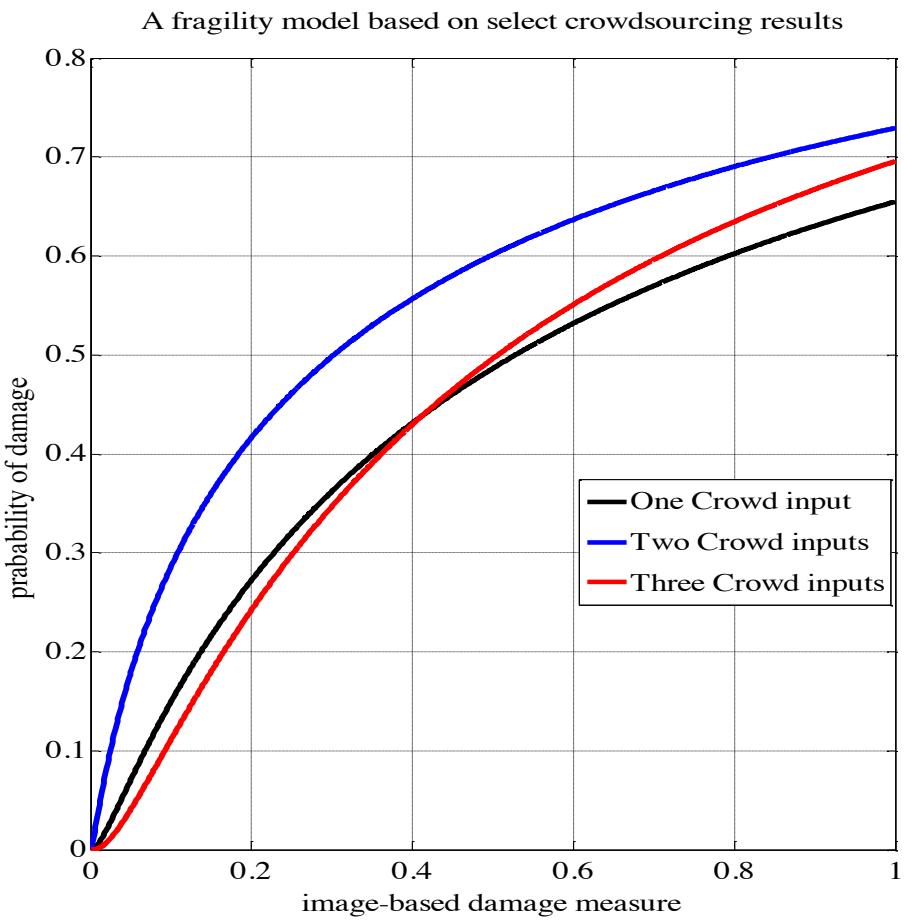
- All detected points are affiliated with their local 'structures'
- Seemly severe damage in the coastline, and the edge lines of the agriculture lands and the airport.
- In built up area, sporadic damage!

Evolving User-input via Crowdsourcing

Example crowd-sourced locations in damaged area

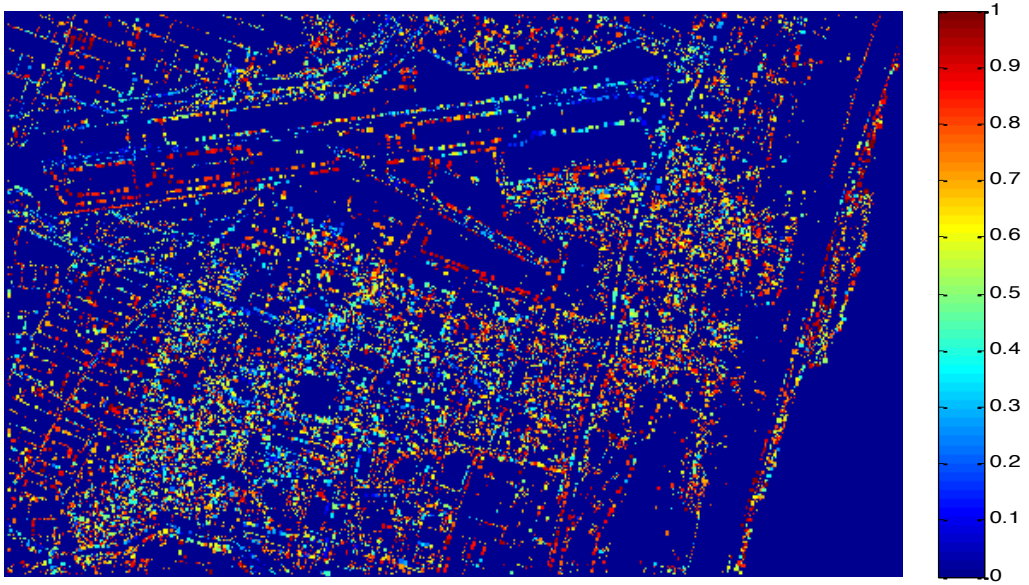
- User-input through crowdsourcing is to be designed and implemented
- Herein a demo: users provide visually identified damaged and non-damaged areas using a mobile phone
- The idea is:
  - User selects a randomly (but structurally interesting object) using a polygon, an ellipse or a simply a point
  - User will simply query the damage level or provide his/her input about the damage level
  - If damage levels are provided, these serve as the training data
  - The underlying computing (in the mobile phone) will determine the coordinates
  - The coordinates will be sent to cloud and merged with the extracted locations of 'key' points

Evolving damage classification



- In the context of CDDM, user may simply report 'collapsed' or 'non- collapsed' (the former includes partial collapse)
- Earthquake engineering community has been using one binary and probabilistic classifier – **the fragility model**, which is simple but much more robust than many other classifiers (e.g. neural nets; support-vector machines)
- In the left, one can see how the fragility (the probability of damage) curves evolve given different number crowdsourcing inputs

Damage Classification Mapping



Damage classification with probability of damage

Crowd-sourced damage classification

- The color-bar indicates probability of damage
- If users (first responders or the public) perform query only through their mobile/web devices, a damage probability measure will be displayed
- The left shows 100 queries using ellipse snippets each of which shows color-rendered probability of damage.